Atlas Technical Note 101

The Atlas Right Light® Filter

Breakthrough Filter Technology for Xenon-Arc Instruments

Atlas Material Testing Technology

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ATLAS MATERIAL TESTING SOLUTIONS / AMETEK®

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1. Introduction

Xenon-arc lamps combined with optical daylight filters have been the most reliable light source for laboratory weathering testing for more than half a century. In laboratory weathering, a close match of the spectral irradiance, especially in the UV region, is essential for realistic testing and the basis for good correlation to natural weathering. There are many optical filters that produce spectral irradiance distributions that are similar to natural sunlight[1]. However, Atlas Right Light is the one that provides the closest match to natural solar radiation. Right Light filters are available for water-cooled Ci Weather-Ometers as well as air-cooled Xenotest instruments. One major benefit of using Right Light is an improved ability to use intensified irradiance levels for shortening of test durations.

2. Matching Critical Short Wavelength UV

For many years, the Boro S/Boro S filter combination for Ci Weather-Ometers or the XENOCHROME 300 for Xenotest was the best daylight filter combination available for xenon-arc instruments. However, while offering a good match to natural solar radiation in the visible and longer wavelength UV range, the UV cut-on is considerably lower. Both produce spectra that contain short wavelength UV below 290 nm while natural solar radiation cuts on between 295 nm and 300 nm (Figure 1). The cut-on mismatch as well as deficiencies in the short wavelength UVA region (320 - 340 nm) were the major drivers for a better daylight filter development.

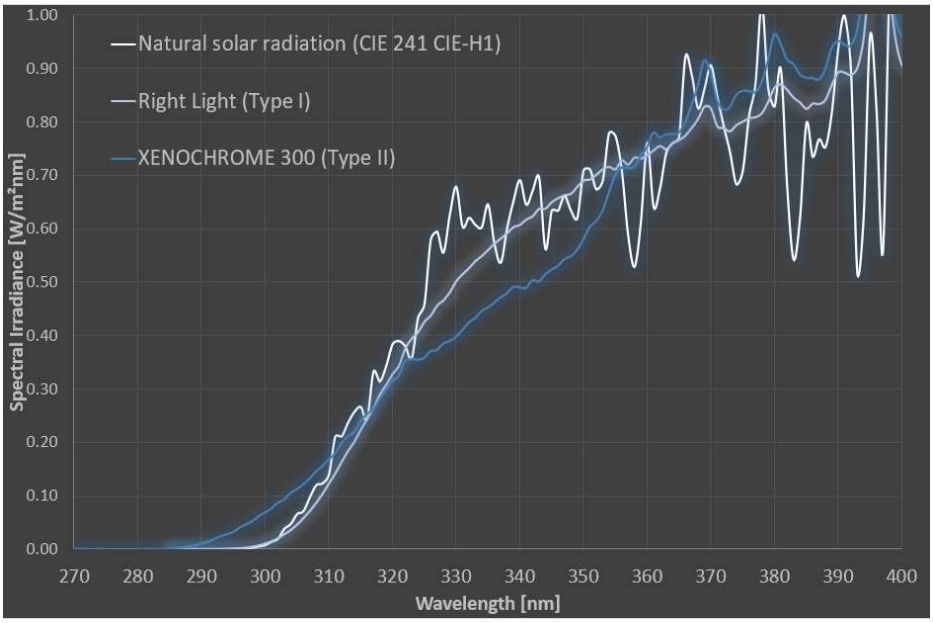

Figure 1: *Spectrum comparison Atlas Right Light®, XENOCHROME 300 and natural solar radiation according to CIE 241 CIE-H1 reference.*

3. Development of the Atlas Right Light Filter

The development of the Atlas Right Light filter was initiated by a joint weathering project for transportation coatings together with Ford, Honda, BASF, Bayer Material Science, and Boeing. This project further initiated the development of an improved weathering standard for transportation coatings - ASTM D7869. Atlas first introduced

the Right Light® filter in 2012 for the Ci Weather-Ometer series. The Right Light® filter for Xenotest was introduced in 2021. The spectral irrradiance of xenon-arc radiation with a Right Light filter combination (light blue curve in Figure 1) does not only show a closer fit of the UV cut-on to natural solar radiation, but also a better match in the mid-UV range between 320 nm and 350 nm.

To allow a wider range of application, the Right Light inner filter of the Ci series can be combined with two different outer filters: quartz or CIRA coated quartz. The quartz filter is more transparent to infrared radiation and therefore allows for higher test temperatures compared to CIRA with IR heat radiation absorbing characteristics beneficial for lower temperature testing.

The Right Light filter for Ci Weather-Ometers needs to be replaced every 2000 hours. For the Xenotest series, a non-aging filter technology is used. It can remain inside a Xenotest for at least 25,000 hours. If no surface damage occurs to the filter, even longer lifetimes are possible (Figure 2).

Figure 2: *Xenotest filter lantern.*

Figure 3 shows the change in the SPD of the UV wavelength region provided by the Right Light filter between 24 and 2000 hours of the xenon lamp lifetime. The relative difference during opperation compared to 24 hours is also shown.

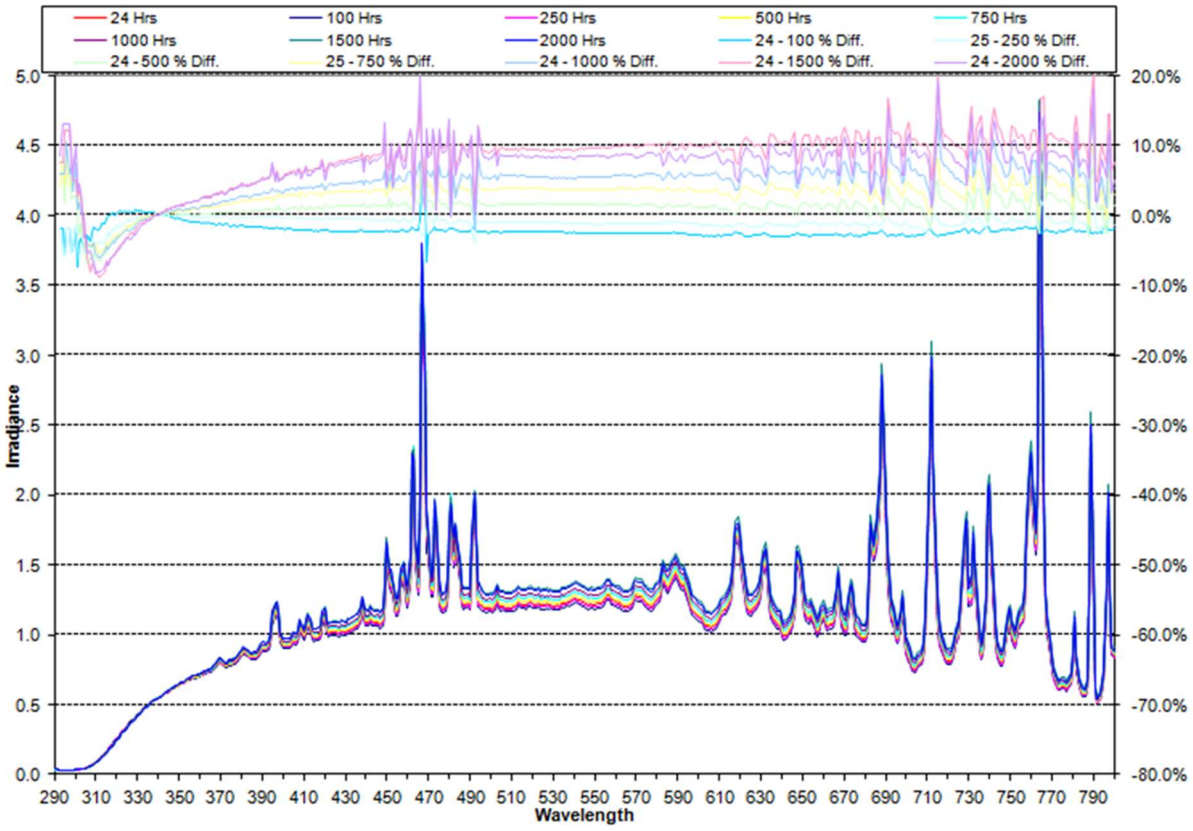

Figure 3: *Spectrum change of Ci Right Light during a xenon lamp lifetime of 2000 h.*

4. Influence of the Spectral Irradiance on Photochemical Degradation

Each photochemical reaction of a polymer has a specific wavelength range which can initiate the degradation process. This spectral sensitivity is described by the so-called activation spectrum (Figure 4). On the other side, there is the spectral power distribution of the light source. Only if there is an overlap between the activation spectrum and the light source, photochemical reactions can be initiated. The overlap is described by the so-called activation spectrum. Different spectral sensitivities and different spectral irradiance distributions (different light sources) will cause different degradation reactions or degradation reactions in different ratios.Most polymers and coatings can degrade via multiple pathways. Therefore, it is essential in artificial weathering for realistic test results and good correlation to use a light source with a good match to natural solar radiation, especially in the UV range.

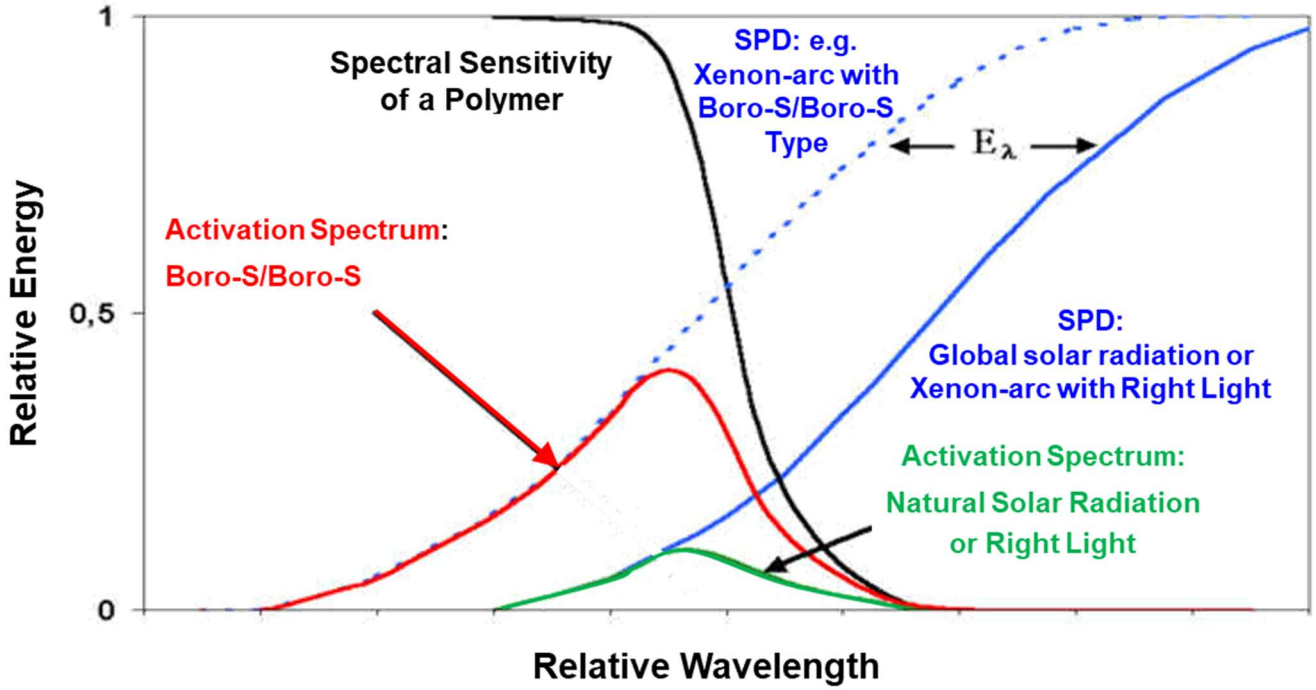

Figure 4: *Spectral sensitivity and resulting difference in activation spectrum depending on the applied spectrum.*

A weathering testing study done by James Pickett et al showed, that with the Right Light filter the relative degradation rate of various polymers with different spectral sensitivities was in the range of 9 % compared to sunlight according to ASTM G177. With the Boro S/Boro S filter system, the degradation rate compared to sunlight showed deviations of up to 87 %.[2] The calculations based on the spectral sensitivity of the polymers have been in good agreement with experimental results. This underlines the important role of a realistic light source, especially in the UV range, in laboratory weathering testing.

5. Standard Weathering Using Right Light

The Right Light filter was first incorporated in international standardization in ASTM D7869. [3,4] It specifies a xenon-arc test protocol for transportation coatings using intensified irradiance, close fit of the spectral irradiance to natural sunlight, and enhanced water exposure. This new test protocol has shown to produce better correlation of test results as compared to traditional methods such as SAE J2527.[4] Another area that picked up the Right Light

technology rather early was the PV industry that worked out the test method IEC 62788-7, a dedicated weathering test for polymeric materials used in photovoltaic modules.[5]

The Right Light filter also meets the requirement of common test methods such as ISO 4892-2 (method A) and ASTM G155 (daylight). The differentiation between original type Daylight filters and Right Light type filters was adressed in 2021 during a harmonized approach by ISO and ASTM standardization committees. As a result, two types of daylight filters – Type I and Type II - are described for ISO 4892-2, ISO 16474-2, and ASTM G155.

- Type I daylight filters have a UV cut-on very similar to natural solar radiation. The Right Light filter types according to ASTM D7869 all fall in to the category of Type I Daylight filters.
- Type II daylight filters have a lower UV cut-on compared to natural solar radiation. The S/S filter combination or XENOCHROME 300 filters are therefore Type II Daylight filters.

Type II daylight filters ave been the state-of-the-art for many years and are still heavily used. However, the newer Type I (Right Light) filter systems gain increasing importance. Therefore, be careful when you compare weathering results produced from different instruments. Always check which type of daylight was used: Type I or Type II?

5.1 ASTM D7869

ASTM D7869 is the first Right Light standard practice for xenon arc exposure testing. It specifies enhanced light and water exposures for transportation coatings. This new test protocol has been proven to produce higher correlating test results, as well as higher acceleration, compared to SAE J2527.[6]

During natural weathering of polyester–urethane clear coats in Florida, the ratio between specific carbonyl and fingerprint peaks (a/b and c/d) in IR spectra evolve in a specific ratio. During artificial weathering testing with radiation sources with high deviation from sunlight, these ratiots deviate. The goal for any realistic light source for accelerated testing is to achieve the same ratio as with natural sunlight.

Step Number	Step Minutes	Function	Irradiance Set Point[1] @340nm (W/m²/nm)	Black Panel Temperature Set Point[1]	Chamber Air Temperature Set Point[1]	Relative Humidity Set Point[1]
1	240	dark + spray	-	40°C	40°C	95%
2	30	light	0.40	50°C	42°C	50%
3	270	light	0.80	70°C	50°C	50%
4	30	light	0.40	50°C	42°C	50%
5	150	dark + spray	-	40°C	40°C	95%
6	30	dark + spray	-	40°C	40°C	95%
7	20	light	0.40	50°C	42°C	50%
8	120	light	0.80	70°C	50°C	50%
9	10	dark	-	40°C	40°C	50%
10	Repeat steps 6-9 an additional 3 times (for a total of 24 hours = 1 cycle)					

***Table 1**: ASTM D7869. 24 hour test cycle.*

Weathering with the Boro S/Boro S (Type II) filter systems according to SAE J2527 gives a good, but not perfect match. A better match can be achieved with concentrated natural solar radiation (EMMAQUA). Also the Right Light (Type I) filter systems result in a better match of the IR peaks. This is a strong indicator that only with a realistic light source the realistic photodegradation behaviour can be achieved.

ASTM D7869 uses long dark phases with water spray for enhanced water saturation of coatings. To compensate the time loss of photo-ageing by these long dark phases and to increase acceleration, ASTM D7869 implements increased irradinace levels (0.8 W/(m²·nm)) above the natural limit in the light phases. Nevertheless, realistic results can be obtained since a realistic spectral irradiance is required.

The ASTM D7869 test cycle (Table 1) has shown to be able to reproduce the following coating failures typically accruing in South Florida with high correlation:

- Cracking
- Blistering
- Adhesion loss
- Color change
- Gloss loss

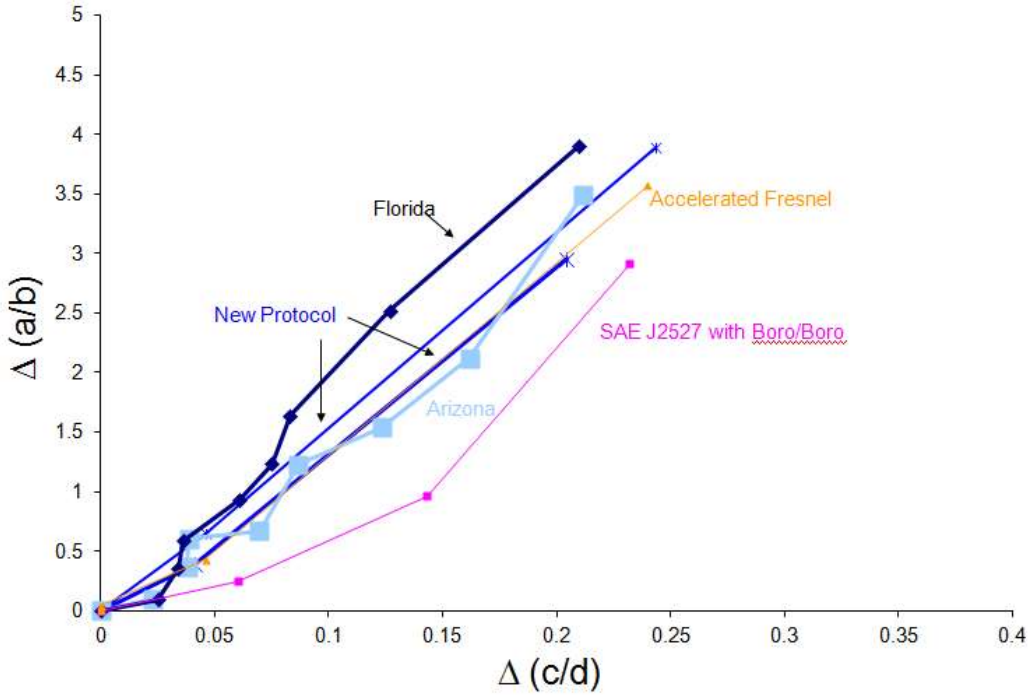

Figure 5: *Laboratory weathering testing of coatings according to ASTM D7869 (new protocol), SAE J2527 (with Boro S / Boro S daylight) compared to natural weathering in Florida (static), Arizona (static), and accelerated outdoor exposure in Arizona using EMMAQUA (Fresnel mirrors).*

5.2 IEC 62788-7-2

The benefit of a better spectrum was quickly adopted by the photovoltaic industry. Standard IEC 62788 describes the measurement procedures for materials used in photovoltaic modules. Part 7-2 specifies the accelerated weathering testing of polymeric materials.

Condition #	Chamber air temperature °C	Black panel temperature °C	Irradiance W/(m²·nm) at 340 nm	Relative humidity %
A1	45	70	0,8	20
A2	55	80	0,8	20
A3	65	90	0,8	20
A4	75	100	0,8	20
A5	85	110	0,8	20 (nominal)

Table 2*: IEC 62788-7-2 method A exposure conditions.*

Today, an increasing number of international standards such as ASTM D3794-16 for coil coatings, ISO 18768-1 and 2 for organic coatings on aluminum, as well as OEM specifications for automotive and consumer electronic applications refer to the Right Light filter or comparable daylight filter types instead of Boro S/Boro S or extended UV filters.

6. Summary

Right Light is a long-lasting daylight filter technology which is available for all Atlas Ci Weather-Ometers as well as Xenotest 220+/440. The spectral irradiance distribution of Right Light meets the requirements of ASTM D7869 and IEC 62788-7-2 and all test methods that specify a daylight Type I filter, such as ASTM G155, ISO 4892-2, or ISO 16474-2.

Right Light supports more realistic weathering testing for all outdoor related weathering applications. Furthermore, like ASTM D7869 or IEC 62788-7-2, it shows that increased irradiance levels above the natural limits (> 60 W/m^2 at 300-400 nm, or > 0.51 W/(m^2·nm) at 340 nm) can work when realistic solar simulation light sources are used.

7. References

[1] A. Riedl, F. Feil, Atlas Material Testing Technology, Spectral Irradiance Distribution and Reference Spectra in Weathering Testing, Atlas Technical Guide TG110, March 7, 2023.

[2] J. Pickett, “How the Relative Photodegradation Rates of Polymers Depend on the UV Source“, 2021.

[3] ASTM D7869, Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings, 2017.

[4] M. Nichols, J. Boisseau, L. Pattison, D. Campbell, J. Quill, J. Zhang, D. Smith, K. Henderson, J. Seebergh, D. Berry, T. Misovski, C. Peters, An improved accelerated weathering protocol to anticipate Florida exposure behavior of coatings. J. Coat. Technol. Res., 10 (2) 153–173, 2013.

[5] IEC TS 62788-7-2: Measurement procedures for materials used in photovoltaic modules - Part 7-2: Environmental exposures - Accelerated weathering tests of polymeric materials, 2017.

[6] SAE J2527, Performance Based Standard for Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Xenon-Arc Apparatus, 2017.

Further information: www.atlas-mts.com

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